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An ultra-capacitor for frequency stability enhancement in small-isolated power systems: Models, simulation and field tests

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Abstract— The most relevant issue in operation of isolated power systems is frequency stability. Frequency stability is concerned with the ability of generators to supply the loads at an acceptable frequency after a disturbance. Frequency stability is governed by the kinetic energy stored in the generator-prime mover rotating masses and the prime mover frequency primary regulation. If frequency excursions are not within +/?2.5 Hz range, cascade tripping of the remaining generators can occur because of generator over/under frequency protections tripping. Energy storage systems can contribute to frequency stability enhancement if their discharging is governed by a frequency controller.

Endesa is leading a research project on testing the state of the art of energy storage systems for several applications (peak-shaving, voltage control, frequency control) in several isolated power systems of the Canary Islands. Several applications are being investigated. One of them consists on the application of a 4 MW-5 s ultracapacitor (UC) for frequency stability enhancement of the La Palma power system.

This paper reports the dynamic model developed for time domain simulation and controller design of frequency stability, and field tests undertaken to validate models and the controller settings. A simple but still accurate model is presented. The proposed model takes into account the UC's state of charge (SoC) and it represents the dynamics of the power electronics by means of a non-linear first-order model. The frequency control consists of droop control and inertia emulation. Ramp rate limits, power limits and SoC are also taken into account in the frequency control. In comparison with the recorded field tests, the proposed model is able to accurately represent the response of the UC for the purpose of frequency stability analysis.

Index Terms— Frequency control; Ultra-capacitor model; Renewable energy sources; Frequency stability

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